

Smart cities choose smart growth

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Abstract: As the world continues to urbanize, sustainable development challenges will be increasingly concentrated in cities. Integrated policies to improve the lives of both urban and rural dwellers are needed. We define a metric to measure the success of smart. We set up an index system that can measure the success rate of urban smart growth to quantify the smart growth of the city, and to judge whether a city's current growth plan is successful.

First of all, we put the current impact of the larger city smart development evaluation index system into a general index database, considering the three E's of sustainability and the 10 principles of smart growth, using Fuzzy set theory to select and classify indexes, then we get a intelligent evaluation with 5 first grade index and 17 secondary index.

We use the arithmetic average method and analytic hierarchy process to determine the weight of each index to smart growth. Because of the difference of the meaning and the nature of the index, the index is different in dimension, so we use the extreme value method to carry on the dimensionless processing to each index value. Thus, we build a model of Urban Smart Growth Evaluation.

Then we chose two cities with a population of less than 500 thousand, collect a large amount of data to quantify the 17 secondary indexes, then judge and analyze their current smart growth in the city. We use the Grey prediction model to predict the trend of population growth for decades, getting the sum of their population, and according to the relevant international standard index judging city demand growth, optimize the current city growth plans.

We analyze the sensitivity of the total evaluation index, adjusting the change rate of different parameters, and assess the sensitivity by the change of the total index. Meanwhile, We get the potential size of different policies in two cities.

We use the index of reliability test method to test the stability of our model, we confirm that the accuracy of our model is high. Broadly speaking, These indicators can be widely used to judge the smart growth of domestic and foreign cities, they are scientific and practical.

Key words: Fuzzy sets, AHP, Grey prediction model, Sensitivity analysis.

1. Introduction

1.1 Problem Background

Globally, more people live in urban areas than in rural areas, with 54 per cent of the world's population residing in urban areas in 2014. In 1950, 30 per cent of the world's population was urban, and by 2050, 66 per cent of the world's population is projected to be urban.

With the emergence of this phenomenon, the existing scale of the city has become increasingly unable to meet people's needs. People began to flow to the suburbs, the extension of the city will continue to expand, the so-called "urban sprawl". The disorder of the urban sprawl makes the use of the existing infrastructure inadequate, resulting in waste of resources, increasing the government's investment in public facilities and costs; Increasing dependence on cars, thereby exacerbating environmental pollution; The imbalance of population and employment leads to the continuous decline of urban centers; Blind land consumption in farmland and environmentally sensitive areas disproportionately associated with population growth.

Thus, sustainable development challenges will be increasingly concentrated in cities, particularly in the lower-middle-income countries where the pace of urbanization is fastest. Integrated policies to improve the lives of both urban and rural dwellers are needed.

1.2 Our Understanding of the Words

Smart growth of a city: How is understand the word ‘Smart city’ is the key to this problem.

At present, people may confuse the smart city and information city. In the information city, the advantages of the suburbs are highlighted, and the development of urban information industry is emphasized, while the smart city is focused on urban construction, to improve the efficiency of high density areas (such as the city center), the efficiency of the input output in the central area is greater, beneficial to the reconstruction of the central area. The key of smart city is the construction of the sustainable development of the city, economic prosperity, social justice and environmental sustainability. Its purpose is to curb the continued spread of the city and the city as the center of the surrounding farmland and reduce the loss.

2. Restatement and clarification of the problem

With the increase of urban population and urban construction becomes more and more important, to make sure that people have social equality and sustainable homes, resources and job opportunities. We need to construct a smart growth community.

1. Define a metric to judge intelligent development of the city, considering the three E's of sustainability and/or the 10 principles of smart growth.
2. The smart degree judging model established by task 1, evaluate two cities' current smart-growth plan, as well as their level of smart growth. (any city with a population of between 100,000 and 500,000 persons)
3. Using smart growth principles develop a growth plan for both cities over the next few decades. Support why you chose the components and initiatives of your plans based on the geography, expected growth rates, and economic opportunities of your cities. Use your metric to evaluate the success of your smart growth plans.
4. Also using your metric, rank the individual initiatives within your redesigned smart growth plan as the most potential to the least potential. Compare and contrast the initiatives and their ranking between the two cities.
5. Suppose the population of each city will increase by an additional 50% by 2050, explain in what way(s) your plan supports this level of growth?

3. Assumptions

We make the following assumption in this paper.

- Some unmeasured factors such the People's ideas has some impact on the smart city, but because it takes a long time to see the impact, had little effect in the short-term study, so we ignored these unmeasured factors .
- We assume that the city will not have a major natural disaster in the coming decades
- We assume that the population growth of the city follows the law of natural growth, and there will be no large numbers of immigrants

- We assume that the demand for the natural environment and the living space of human beings is basically to meet the international standards

4. Symbol Definition

Parameter	Meaning
X_i	The value of the objective I
W_i	The weights of the objective I
F	Sample urban indexes
Max X_i	Maximum index
Min X_i	Index minimum
α	Reliability coefficient
n	Number of indicators
S_i	The variance of each index
S_t	Total score for all indexes

5. Models

5.1 Evaluation model

5.1.1 Indexes system synthesis

To measure a city's smart growth, we build up measurement model. This model consists of five dimensions, 17 indexes.

So far there is no unitized evaluation indexes system for urban smart growth internationally. If we want a wide application measurement indexes system, we will have to combine the most influential measurement indexes systems into one comprehensive indexes library. These indexes library summary urban smart growth measurement indexes at home and abroad. As for the domestic indexes, we selected 10 indexes from the past 3 years to guarantee we have up-to-dated indexes. As for the abroad indexes, we selected 10 indexes from Japan, Korea, America, Canada, and Australia, Europe Union and other countries and areas, to insure we have extensive indexes. We selected the following indexes to make up the indexes library based on our definition of smart city and consideration of three E and ten principals for smart growth. They are: GDP, urban population density, urban volume rate, per capita disposable income, changes of agricultural land area, water resources per capita, changes of agricultural land per additional person, per capita green area, built-up area green rate, air quality rate, per capita area of roads, ownership of public transportation vehicles per

million people car, ownership per capita, unemployment, inequality, education penetration rate, healthcare penetration rate and so on.

5.1.2 Indexes filtering:

After we got the overall library, we moved to the indexes filtering process. Main take of method has: 1) Delphi method (or based on experts scoring of AHP method) .through experts scoring, build indexes membership function, retain high points indexes, delete low points indexes, , then based on that work on correlation test and other indexes filter work;

2) According to different scholars' understandings on city smart development, select indexes by experience. Due to different understandings of the urban smart growth in different researchers' eyes, use empirical methods to filter the indexes in order to avoid subjectivity issues.

To construct reasonable indexes system, we used membership functions. Using the frequency of indexes to explain its membership, we retained indexes with high membership, and removed indexes with low membership. We filtered the indexes after reorganization, the filter selection process is as follows: 1) synonymous substitution, retain one representation in synonymous or antonymic expressions, delete redundant indexes; 2) observability test, remove invisible indexes; 3) based on fuzzy set membership filter, delete indexes with low membership.

5.1.3 Indexes classification:

According to this ten principles, we summary out main content for "smart growth": 1) land using: full using of land in built district, parallel construction of new and old city, mixed using of land, compact building design; 2) resources and environment: prevent damage of ecological land like farmland and scenic land from use of economic land, city environmental planning lays emphasis on ecology; 3) public traffic: community planning walk-orientation, transport diversification, change of excessive rely on car ; 4) other: avoid expansion of live conditions differences, full policy effectiveness calculation. See basic content of "smart growth", we established integrated indexes for "smart growth", including 5 dimensions like urban development, natural resource conservation, environmental quality, traffic quality and social equity.

(1) Urban development. Urban development is a complex process. From a geographical perspective, urban space growth reflects the external growth and internal growth, external growth tends to the proliferation and development in the urban fringe, internal growth tends to be within the existing urban area, focus on the construction and planning of central area. Every development model depends on the growth of people, the economy and areas. "Smart growth" emphasized the control of city boundaries, the increase efficiency of land use. So population density in cities, urban areas, urban capacity rate, GDP and disposable income per capita indexes are concerns of "smart city" development model.

Table 1 index of urban growth pattern

Second grade index	Units	Nature	Identification
GDP	dollar	Positive	X1
Urban area	Square meter	Positive	X2
Urban population density	%	Positive	X3
Urban volume rate	/	Negative	X4
Per person disposable income	dollar	Positive	X5

(2) Indexes of Natural resource conservation. One of the objectives of Smart growth is to realize the urban smart growth by making full use of existing land to protect agricultural land, water resources and other natural resources. Per capita water resources amount to measure the protection of water resources, agricultural land area change in agricultural land changes per additional person can serve as an index of the city's conservation.

Table 2 index of natural resources protection

Second grade index	Units	Index Interpretation	Nature	Identification	(
The change of agricultural land area	%	Percentage change in agricultural land in recent years	Positive	X6	3)
Water resources per person	m ³	/	Positive	X7	Index
Changes in agricultural land per person	Mu	Changes in the number of agricultural land per person added in recent years	Positive	X8	es of

h" policy covers the concept of sustainable development. Improve the quality of people's living environment through the protection of arable land, gardens and improvement of environmental quality. In the 17 indexes, there are indexes like per capita green area, built-up area greening rate, and air quality that can effectively measure this index.

Table 3 urban environmental quality index

Second grade index	Units	Nature	Identification
Per person park area	m ³	Positive	X9
Greening rate of built-up area	%	Positive	X10
Air quality rate	%	Positive	X11

(4) Indexes of traffic quality. Most of the smart growth model focused on urban form--compact development, higher density, mixed use, reconstruction of the city center as well as protection of agricultural land and environmentally sensitive areas. But these were only effective after we build right regional traffic system. In the 17 indexes we picked out indexes

like per capita area of roads, ownership of bus per million people, per capita car ownership to measure traffic quality.

Table 4 urban traffic quality index

Second grade index	Units	Nature	Identification
Per person Road area	m ³ /person	Positive	X12
Number of buses per million people	/	Positive	X13
Per person car ownership	%	Negative	X14

(5) Indexes of social equity. One important index of sustainable city is social equity. Only if we have social justice, employment, equal opportunities, small gap between the poor and the rich, our people will be happy, our society will be harmonious, our city will become a smart city.

Table 5 social equity index

Second grade index	Units	Index Interpretation	Nature	Identification
unemployment rate	m ³ /人	/	Negative	X15
Poverty gap	/	Gini coefficient	Negative	X16
Popularization of Higher Education	%	/	Positive	X17

Thus we have the city "smart growth" measurement indexes system, consisting of 5 dimensions of 17 indexes. These 17 indexes can be quantified, some directly reflects the city's "smart growth" levels, and some indirectly reflects the city's "smart growth".

5.1.4 determining indicator weight

Method of determining the index weight common scoring method and AHP method, the method of principal component analysis and arithmetic average, scoring and analytic calculation of containing some subjective judgement links lose objectivity. Principal components analysis only applies to the weight of a single annual measure. Arithmetic mean method does not take into account the weight of each indicator to the level indicator on the different. We do not individually using either method to make sure we get the weight of each indicator.

From the above analysis, we can know, first grade index plays an important role to measure the success rate of the degree of city smart and 5 indicators of the first grade index appears similar to the frequency in different target system which demonstrate applicability of the level indicators is strong, so first grade index weight of smart growth use arithmetic average method. And secondly index weight based on fuzzy collection of membership degrees filter removed has part index, and retained of index in different index system appeared of frequency does not similar, which can see two level index on a level index of weight not should completely same, at consider level analysis method of thought, on all a

index Xia of two level index for 22 compared established into on compared matrix, and on matrix for consistency test, if through consistency test is calculation out matrix of right vector, last get two level index on a level index of weight. Need to note is the use of these methods is not an end, but only the index merge, making it easy to do further analysis on the results. This weight is obtained as shown in table 6.

Table 6 city smart growth degree measurement index weight assignment

Target	First grade index			Second grade index	
	Name	weight	Identifi- cation	Name	Weight
Smart growth	Develo- ment model	1/5	X1	GDP	0.0738
			X2	Urban area	0.1209
			X3	Urban population density	0.2147
			X4	Urban volume rate	0.3760
			X5	Per person disposable income	0.2147
	Natural resour- ces protecti- on	1/5	X6	Agricultural land area change	0.1365
			X7	Per person water resources	0.2385
			X8	Changes in agricultural land per person	0.6250
	The quality of environ- mental	1/5	X9	Per person park area	0.1365
			X10	Greening rate of built- up area	0.6250
			X11	Air quality rate	0.2385
	Traffic quality	1/5	X12	Per person road area	0.2583
			X13	Public transport vehicles per million people	0.6370
			X14	Per person car ownership	0.1047
	Social equality	1/5	X15	unemployment rate	0.1172
			X16	Poverty gap	0.6144
			X17	Education Popularization	0.2684

5.1.5 Dimensionless index

Index of dimensionless, also known as the standardized data. Selected of 17 a index due to different meaning and different nature ,led to index in dimension aspects exists differences, to elimination differences dimension on evaluation measuring of effect, we need on all index numerical for infinite outline of processing: selection what method on data for infinite outline of processing, need according to requirements of data nature and data results to determine, which extreme of method on index data of number and distribution status requirements lower. Relative number nature of the processed data is more obvious. And will avoid the appearance of negative numbers, and to facilitate the further data processing. Therefore, The evaluation index system use the method of extreme value in this article, the

formula is as follows:

$$\begin{aligned}
 (1) \text{ Positive indicators: } & Xi = \frac{Xi - \min Xi}{\max Xi - \min Xi} \\
 \text{Negative indicators: } & Xi = \frac{\max Xi - Xi}{\max Xi - \min Xi}
 \end{aligned}
 \tag{2}$$

5.1.6 the establishment of comprehensive evaluation model

For a particular city, according to each index after data collection and normalization, we have 17 second-level indicators based on the weight of each index,, further synthesis of 5-level indicators, finally can get in every city "smart growth" levels of total index, specific methods are as follows:

$$(3) \quad F = \sum_i^n (Wi \times Xi)$$

Where f represents urban elements indicators index, w, on behalf of I-th weight of x. On behalf of the host city of the I-th objective indicators

5.1.7 Index reliability test

The reliability analysis of indexes guarantees indexes'inner stability and reliability. In brief, the smaller the disparity between two measurements of one index, the higher the reliability is. On the contrary, huge disparity between two measurements of one index indicates low reliability and lack of stability.

In this paper,we use Cronbach's alpha which is the main reliability coefficient to have reliability analysis.The Alpha coefficient formula is as follows:

$$(4) \quad \alpha = \frac{n}{n-1} \left(1 - \sum \frac{Si}{St} \right)$$

There are five dimensions of the index system, to examine the consistency between the scores of each item according to the Alpha coefficients of each dimension. Analyze the internal consistency of the five dimensions of index by using the SPSS, Alpha coefficient of the five dimensions are: 0.8134, 0.8387, 0.9412, 0.8510, 0.9360, 0.8722 in the four dimensions of reliability coefficient of 0.8 ~ 0.9, that is four dimensions in the index to describe accurately, without further modifications. The reliability coefficient in 0.8 ~ 0.9, indicating acceptable reliability, does not need to be modified. And then use the method of all indexes on the index system of internal consistency analysis, the internal consistency reliability coefficient was 0.9001, indicating the reliability of index system of good, good stability, can be used to determine whether most of the city is city smart growth.

5.2 Model application

5.2.1 Plan analysis

1. Jiayuguan

The publicity of Urban Master Planning of Jiayuguan(2012-2030) shows the city's growth plans.

- Economic development planning :Jiayuguan area GDP reaches 280 billion yuan, the per capita GDP reaches about 490,000 yuan, the proportion of the three - industry structure adjusts to 1:64:35 by 2013.
- Ecological environment goal: basic farmland area is not diminished, the quality of agricultural environmental remains stable, the city's environmental monitoring capability is significantly enhanced, initially built up a resource - conserving and environment - friendly society. Centralized treatment rate of urban domestic wastewater reaches 100%, harmless disposal rate of urban domestic garbage reaches 100%, green rate of urban built-up area reaches above 35%, urban per capita public green area reaches above 12 square meters.
- Green area of the city center and squares reach a land area of 956.93 square kilometers, accounting for 11.96% of urban construction land, 17.70 square meters per capita. 956.93 square kilometers consists of 734.01 hectares the Parkland area, which accounts for 9.17 of urban construction land and 13.35 square meters per capita. The rate of urban green space reaches 35%, green coverage of 40%, which meet the national ecological garden city standard.
- "Four lines" urban construction control: overall planning of the lines to delimit the purple, green, and blue line, the yellow line, such as "four lines", and formulate relevant planning control requirements, city planning of land use and shall abide by the "four lines" construction plan of the control.
- Cultural construction: rely on the Great wall World Heritage and a variety of historical relics, combine with the Hexi Corridor, the Silk Road, and Desert scenery, create distinct regional characteristics, strong cultural heritage of the desert pearl.
- Urban development direction: the major urban development direction is eastward and southward, which is opposite of the direction of Jiuquan, advancing the integration of Jiuquan and Jiayuguan. Follow the development pattern of integration and group layout , the city center of Jiayuguan forms " two scenic belts, three areas, six groups " urban spatial structure.
- Regional transportation planning: establish a modern comprehensive transportation with improved network infrastructure, complete hub functions, efficient and convenient service, increase network density, promote the expressway and national highway encountered engineering, improve the road network structure.

We can see the Jiayuguan city growth plan roughly follows the ten principles of smart growth. In economic development program planning, regional GDP per capita is in accordance with the requirements of the sustainable development of the social prosperity. In the ecological environment protection, multiple policies towards farmland area, environmental quality and all sorts of green area are to follow the ten principles of "keeping open space, farmland, natural landscape, and key environmental zone" this principle. And in the planning of cultural construction is the joint of smart growth in emphasizing on the principle of unique, with strong local characteristics. Planning to

establish a network of facilities and transportation system offers a variety of transportation options for people, improve people's travel convenience. "Four lines" urban construction control is to strengthen and led the development of the city, guarantee the economic common development.

2. Longueuil

- Open by default is about providing
The Canadian government pledged to "Open by default" to share government data and information when it is feasible as to provide the public interest, support for citizen participation and strengthen the accountability system
- Increase the present residential density in the center of the city, reduce the occupied area of each household. Make the population and employment positions grow along the planned of public transport corridor.
- Perfect the light rail and even the conventional public transit network planning, as to enable people to select the most appropriate way to travel and improve service quality and competency of the track traffic system and the conventional public transportation.
- It is the good urban design and the pedestrian-targeted designs of streets and the buildings but cars that create a high-quality public space to encourage people to walk or use public transport as much as possible.
- The protection for green space must be transformed from theory reality, which will be invested 13.5 billion \$.
- Open by default is about providing easy and consistent access to government data and information in open, standardized, digital formats. This gives Canadians the tools and information they need to hold government to account.

Plan 2 reasonably improved the downtown residential density, optimized the original residential area, maximized the usage of compact design and also mixed and matched the land resources, creating more housing opportunities and choices. Besides, it added more traffic mode choices and increased traffic area, which meet the requirement of the principle, offering a variety of means of transport and building walking the streets. Good growth plan should take the environmental sustainability into account. Considering this, Longueuil city increased the investment on green space. So the growth plans of Longueuil city in Canada and the ten principles of smart growth are in high accordance.

3. Evaluate the growth plan

The following is our collected jiyuguan and Longueuil each index data of the same year, are shown in table 6.

Table 6 index data of Jiayuguan and Longueuil

	JiaYuGuan	Longueuil
Total population (person)	241300	241606
GDP(Billion dollar)	20	80
Urban population density (person / square kilometer)	3900	1984
Urban volume rate	2	2.8
Urban area (sq km)	60	115.59
Per person disposable income(dollar)	2500	25000
The growth rate of Agricultural land area (%)	1	2.5
Per water resources (cubic meters)	1257.1	4000
Agricultural land change per mu (MU)	0.18	0.22
Per person park area (square meters)	36.3	50
Greening rate of built-up area (%)	37.6	40
The rate air quality excellent(%)	82.7	97.2
Per person Road area(square meter)	16.37	20
Per person car ownership (unit)	0.149	0.62
Public transport vehicles per million	6.1	6.2
Unemployment rate (%)	2.7	6
Poverty gap(Gene coefficient)	5.2	3.3
Education Popularization(%)	14.66	50

Using the model 1 and model 2 above draw the success rate of city smart growth evaluation model combination of collect of JiaYuGuan and Longueuil related information, we can calculate the "smart growth" degree index of them.

Tab.7. "smart growth" index scale

First indexes	Weight	JiaYuGuan	Longueuil
Growth model	1/5	0.214	0.577
Natural resources conservation	1/5	0.314	0.665
Environmental quality	1/5	0.578	0.799
Traffic quality	1/5	0.378	0.447
Weighted aggregation	1/5	0.351	0.423
Weighted aggregation		0.367	0.582

Tab.7 indicates that the index in JiaYuGuan is just 0.347 which is lower to the average index, showing that the current city smart growth plan needs to be improved. The

particular growth plan in Longueuil enable the urban smart growth degree index up to 0.582, and enable the urban develop sustainably, but in performance can only be as good according to the priority.

In terms of development pattern, Longueuil index is 0.577, JiaYuGuan indexes of only 0.214. In the city of jiyuguan city GDP in the same population is higher, but the proportion of economic structural is imbalance, jiyuguan city is an industrial city, industrial production take way more proportion in the gross domestic product, causing the problem of low per capita disposable income, so far from longueuil. Before and jiyuguan due to excessive exploitation of excess production capacity, the old industrial area gradually decline, while the decaying industrial area into the market is slow, the urban land underused urban each function is dispersed at the same time .jiyuguan city blind development new led to the development and utilization of old city is not fully ,so the current development plan needs to be improved and longueuil urban development is good, Canada belongs to the developed countries, the national economic income is high, sparsely populated, per capita disposable income is high also, urban area is big, the land high mixing rate.

Natural resources protection, the index of jiyuguan is still low, and longueuil 0.665 .jiyuguan is located in the northwest, imbalance of land, water and land resources are scarce agricultural land accounts for less, current growth plan is not shrewd long yi city is humid continental climate, with abundant rainfall, rich in water resource, and farmland resources get better protection, the index grade is higher, shows its current natural resource protection plan is good

Environmental quality, jiyuguan index was 0.578 more than average, the urban environment is good, that growth plan basically met environmental sustainability Longueuil as a tourism developed city, city's green area is big, good air quality, the index is as high as 0.799, shows that the growth of the environmental quality plan high success rate.

In terms of traffic quality and social equality, longueuil two index is higher than the jiyuguan pass, but also lower than the average, to illustrate the two cities in urban residential area development and construction, not a good path matching, give attention to two or morethings in the growth of the construction of urban public transportation plan remains to be improved. For unemployment, longueuil is currently 6%, unemployment is high, and jiyuguan although the unemployment rate is good, but the gap between the rich and the poor, education popularity is not high, low and social fairness. Traffic quality and social equality growth plans remains to be improved.

5.3 Improved Model

5.3.1 The Foundation of Model

First of all, We turn to the ten principles of smart growth as a planning guideline and principles. Combined with the city's own geographical location, economic development opportunities, as well as the city's own expected growth rate, targeted and comparison for the two cities to develop growth plans.

Based on the ten principles of smart growth, we came up with a smart growth plan:

- Accelerate the construction of urban infrastructure:Overall short-term and long-term development needs of the city and strengthening road traffic, public facilities, sewage

treatment and other urban infrastructure construction, increasing the bearing capacity of the city, perfecting urban functions and meet the needs of urban development, establishing safe and efficient modernization of municipal infrastructure systems.

- Integrated urban space layout: Strictly control the proliferation of cities, strengthen growth management measures, in particular, strictly controlling the growth boundary. Commercial, residential, public services, industry and so on to balanced development.
- Traffic development goals: Improve urban traffic organization in the context of the city perfect city secondary road network, improve highway coverage, improving the per capita area of roads and energetically develop public transport; the Government invest more in revenue to maintain the roads now, while building more pedestrian walkways, and strongly supported the carpool (carpool), cycling and walking.
- Increase the supply of affordable housing, improving rental housing and multi-family unit availability. And supports the compact design, the renovation of existing gated communities
- Environmental protection plan: City will spend more on the protection of green spaces, creating garden cities, build more green space parks; transformation of agricultural land to non-agricultural land, protection of water resources, increasing the amount of per capita water resources.
- Harmonious society target: Through economic plans of optimization industry structure created more employment opportunities, while government input more of revenue to strengthening employment training, to reduced unemployment, expected to reduce unemployment from the current 50%; 1.5 times increase educational input to an existing plan after 20 years in post-secondary education increases the proportion of the population than the current 1.5 times; enhancing the functions of the Government in regulating income distribution and increase taxes on high earners, thereby reducing the gap between rich and poor. Gini coefficient is expected to meet international standards.
- Based on the ten principles of "creating more housing opportunities and choices", the city required provide all income levels to meet the quality standards of housing options, improve housing affordability and selectivity of mixed housing for low-income families. Increase the supply of affordable housing, improving rental housing and multi-family unit availability.

These are two macro-development plan of the city, however an urban development plan and the city's geography, economy, trends in population growth are inextricably linked. We will continue to analyze the location, development needs and economic opportunity of Longueuil and JiaYuGuan and give two cities expected to be reached in a 20-year development target

5.3.2 a combination of factors

1. Grey forecasting model

With the increase of population, on the premise of controlling the city boundary, the carrying capacity of the city also needs to improve, urban smart growth indicators also need to improve the relationship, so for the urban development of a growth plan, you need to simulate the demographic trends and development. Population reproduction of the system is determined by birth, death, disease, disaster, environmental, social, economic and other factors affects and restricts the result, so many factors that cannot be expressed through several indicators can clear their impact on population growth potential and the complex is even less precise calculations that reflect the system has obvious grey, suitable for use of grey model to explore and know its original integrated time series gray matters covered in internal law. According to the history information on factors that influence the urban population

change, with discussion on the changing pattern in time, we can draw the city long-term trends in population size and to predict future changes in it. But, due to effect city population scale changes of factors many, and some factors is not completely determine of, to increased has information gets of difficulty, effect forecast results of precision. grey forecast method is a on both contains known information and contains not determine factors of system for forecast of method, it of features is by needed information less, not only can will disorder discrete of original sequence into for ordered sequence, and forecast precision high, can keep original system of features, better to reflect system of reality

2. JiaYuGuan

- Population growth trends: Checking out the JiaYuGuan statistics population statistics and JiaYuGuan city in recent years of Government work report we obtained the JiaYuGuan city population date from 2010 to 2015. And use the GM (1,1) model to Jiayuguan city population forecasts for the next 20 years is as follows, see Fig.1

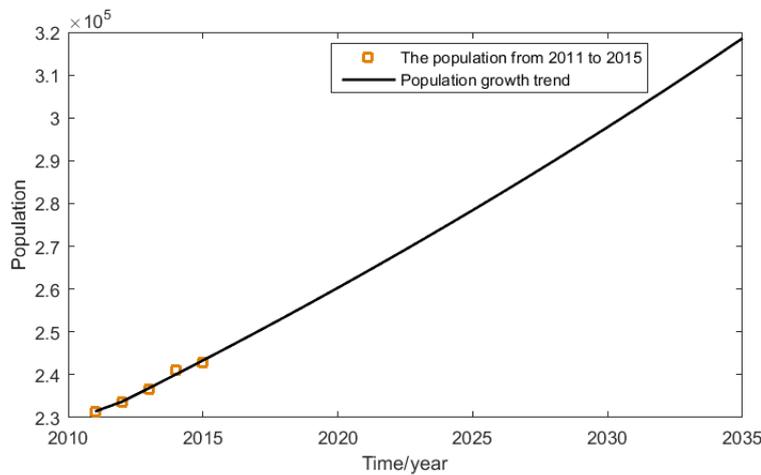


Fig.the Jia YuGuan city population date from 2010 to 2015.

- Jiayuguan in Northwest Gansu province, China, in the middle of Hexi corridor, geographic coordinates in longitude 98 °, 39 °, 776 km from the provincial capital of Lanzhou. Jiayuguan has a continental desert climate, average less natural rainfall, scarcity of water resources, water resources per capita is lower than the international average, Jiayuguan to achieve smart growth is to protect water resources, increasing the amount of per capita water resources. Located in the Northwest, soil resources are scarce, Jiayuguan imbalance of land, agricultural land accounts for less, in the future more needs in the development of non-agricultural land into agricultural land. Jiayuguan city and Jiuquan city, central to the western edge of oasis in Jiuquan and Jiayuguan city green area is large, but the per capita green area is still low by international standards, so building parks to increase the per capita green area.

- Economic conditions: Higher in the city of Jiayuguan city, gross domestic product in the same population, but the proportion of economic structure imbalance, Jiayuguan city, belongs to the industrial cities, total industrial production in the GDP accounts for too large. The Jiayuguan City Bureau of statistics data showed that, Jiayuguan GDP decreased after 2012. , And in the process of urban development, gradual decline of old industrial areas, decaying industrial areas into the market slowly, urban land have not been fully utilized, the Ribbon is dispersed in the city and new town led to the old city of Jiayuguan city, blind development is not fully developed and used. To achieve smart growth, first of all to make the transition, encourages the development of the tertiary industry and science and technology industries, to stimulate urban economic development and bring more revenue to the Government and urban

growth boundaries, speeding up renovation of old industrial areas and the old city to encourage compact building design.

3. Longueuil

• Population growth trends: Checking out the Longueuil statistics population statistics and Longueuil

city in recent years of Government work report we obtained the Longueuil city population date from 2010 to 2015. And use the GM (1,1) model to Longueuil city population forecasts for the next 20 years is as follows, see Fig.2

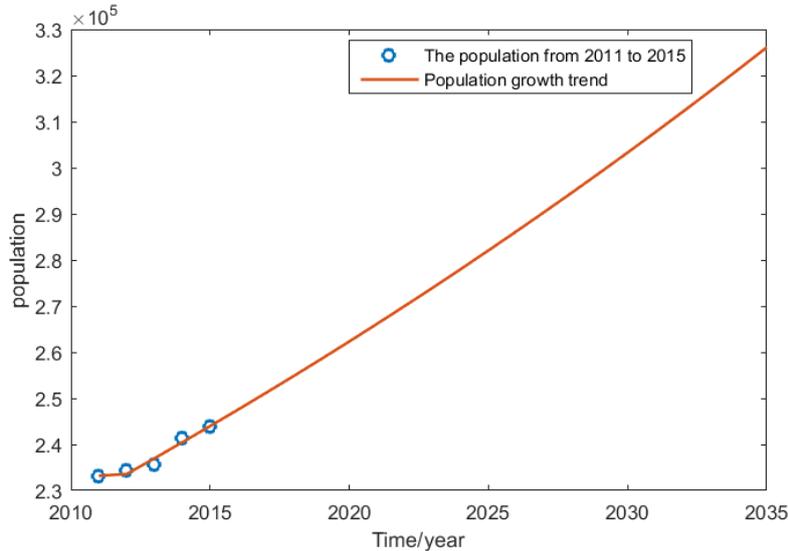


Fig.2 the Longueuil city population date from 2010 to 2015.

• location and geographical conditions: Longueuil is located in the Saint Lawrence River Valley is a wide plain. Longueuil municipal humid continental climate, abundant rainfall, rich in water resources and farmland resources are better protected through index score above, langjier developed in environmental quality and natural resources protection, Longueuil conservation of the existing natural resources policy is good, does not require too much optimization, similarly, by index scores can be seen, high environmental quality of langjier;

• Economic opportunity: Developed city of Longueuil, but the proportion of high-tech industry is relatively small, based primarily on tourism and industries, in such conditions, to make the transition, the transformation of traditional industrial areas, while encouraging innovation in order to stimulate economic development, increase per capita disposable incomes to ensure steady growth in GDP.

5.3.3 Specific plan of two cities

From the above proposed growth plan and taking into account their respective geographical environment, expected growth rates and economic plan, we give the Jiayu pass and Longueuil specific growth plans.

Table 8 indexes of two cities

Policy	Policy related content	Expected goal	
		JiaYuGuan	Longueuil
Traffic plan	Per road area (square meters)	16	18
	The number of private cars per person (unit)	0.2	0.6
	The number of buses per million people (number of vehicles / table)	8	8
	The growth rate of Agricultural land area (%)	1.5	1.8
	Urban per park green space (square meters)	16	18
Environmental protection plan	Increase the green coverage rate (%)	39.5	42
	Good air days (days)	300	345
	Per water resources (cubic meters)	1400	8500
Urban construction plan	urban population density (%)	4500	2400
	THE growth ratio Urban area growth ratio (%)	2	2
	Urban volume rate	2.5	2.2
	GDP (Billion dollar)	30	18
Economic development plan	Per person disposable income (dollar)	4000	30000
	Education penetration (%)	30	60
Building a harmonious society	Unemployment rate (%)	2.5	4.5
	Poverty gap(Gene coefficient)	0.45	0.4

Thus,we can obtain smart growth index of cities from model I and model II

Table 9 smart growth index of cities

First indexes	Weight	JiaYuGuan	Longueuil
Growth model	1/5	0.344	0.577
Natural resources conservation	1/5	0.604	0.695
Environmental quality	1/5	0.678	0.812
Traffic quality	1/5	0.438	0.617
social equality	1/5	0.421	0.513
Weighted aggregation		0.5704	0.643

So, after our growth plans, Jiayuguan city, "smart growth" index 0.5704, than the original development plan has greatly improved. Because of the original city of Longueuil growth plan is better, the improvements we have proposed plans to Longueuil "smart growth" increased marginally.

6. Sensitivity analysis

6.1 Optimal planning

Analysis and evaluation of the sensitivity of F, By adjusting the development model, the size of the relevant parameters of natural resources protection, environmental quality, traffic quality and social equality, through various plans impact on the total index size evaluation divided its potential size.

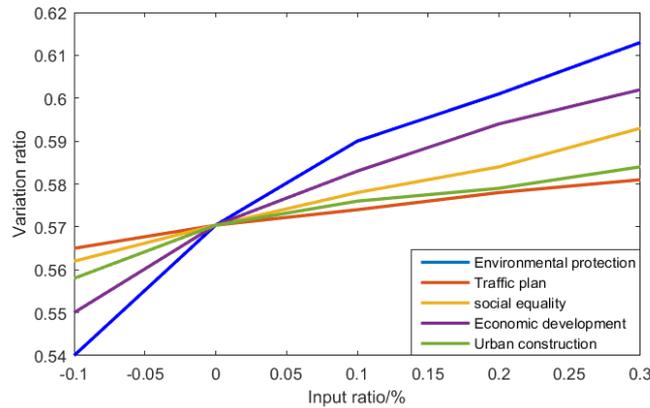


Fig.3 Sensitivity analysis of JiaYuGuan

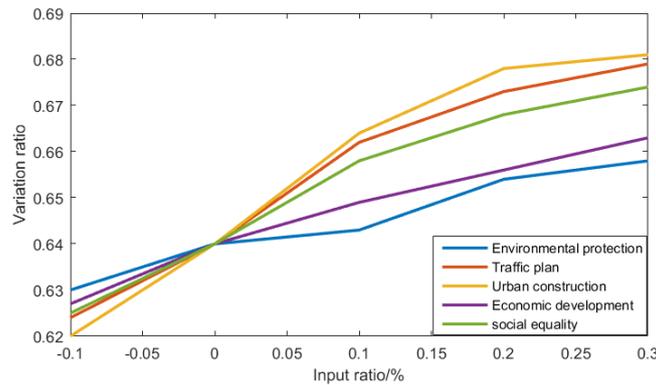


Fig.4 Sensitivity analysis of Longueuil

It can be seen from the two analysis figures that the influence of the change of the parameters on the F index is stable, and the success rate of the city's intelligent growth can be changed to varying degrees by adjusting the rate of change of the planning indicators, but the contribution of each parameter to the total evaluation index F is different. It is concluded that for JiaYuGuan, the plans ranked from the most potential to the least potential are: Environmental protection plan, economic development plan, building a harmonious society, urban construction plan, traffic plan. For the city of Longueuil, the plans ranked from the most potential to the least potential are: Urban construction plan, traffic plan, building a harmonious society, economic development plan, environmental protection plan.

6.2 Explanation and description:

The potential of each plan in two cities is closely related to the actual situation and development needs

1、 For JiaYuGuan

Analysis by task 3, JiaYuGuan is a water shortage city, located in the Northwest, farmland, green space and other environmental conditions are poor; And it can be seen that the index of environmental quality and natural resources protection is the lowest. So to improve the success rate of smart growth, first, government should pay attention to the improvement of the environment, this is also consistent with the ten principles of "preserving open space, farmland, natural landscapes, and critical environments"; Refer to JiaYuGuan City Bureau of JiaYuGuan, the last ten years GDP statistics, it can be found that in recent four years, the GDP of JiaYuGuan has decreased year by year, because of the irrational economic structure in JiaYuGuan, critical dependencies on industries, with overcapacity, industrial recession, economic of JiaYuGuan downturn, and this directly affects the government's investment in urban infrastructure, at the same time, the decline of the industrial zone land use efficiency. So the city needs to grow, must pay attention to economic development; JiaYuGuan social equality index score is low, limited to the level of social development, in the short term is difficult to have a greater improvement, smart growth also requires equality and democracy in the community, so the potential for building a harmonious society has great potential for development; JiaYuGuan urban development level is not high, did not reflect the principle of smart growth in the "land mixed use" and "compact architectural design", but the urban development is relatively late and the urban planning is reasonable; Judging from the scoring of JiaYuGuan, we can see that the traffic quality of JiaYuGuan is high, and the secondary indexes of the relevant data has reached the national standard, so the potential is minimal.

2、 For Longueuil

Analysis by task 3, Due to the superior geographical position, Longueuil city is rich in natural resources, environmental conditions, which is also reflected in the index score, so the potential for environmental planning is minimal. But index scores of Longueuil in the growth model is relatively low, because Longueuil has good economic development, and people's lives rich, while the city volume rate is higher, and the population density is low, so government can increase the existing land use intensity and the transformation of the old city, improve the proportion of land use to achieve the city's smart growth, so the potential for urban construction projects is the largest.

7. Model reoptimization

If the population of the city increased 50%, so many conditions have to be changed in the urban development process. Due to population growth and economic, environmental, social and cultural interaction, we assume that when population growth, all other conditions being the same. Then study urban change according to our model index. At last, we will combine with our third mission and plan how to support population growth.

The population of JiaYuGuan city and Longueuil city are similar. We unified hypothesis only here. Assumed population in 2050 increased 50%, that population would reach 360,000. According to assumed, basic situation changes of city results for:

- 1) Under control of the population border growth not over 2%. When density of population further increases, the survival space would further reduce. City survival pressure would also gradually increase;
- 2) Per capita resources share sharply declined, per capita green area, and per capita water resources would down to below national standards. Agricultural area would be extrusion and the area is reduced trend;
- 3) Traffic quality would be poor. For that public transport cannot satisfy the needs of people and traffic congestion serious;

4)The increase in population will also increase employment pressure and increase the unemployment even the social atmosphere of oppression. Beside, Social harmony index fell sharply.

Therefore, in order to support the growth of population, we need to avoid the occurrence of these results. We can conclude that if population increases 50%, we should support population growth by these four ways:

(1) In city construction plans aspects, to forecast that the population growth may bring pressure, planning city regional reasonable and focused on traffic route of design. In accordance with ten principles of "mixed land using" and "encourages compact type building" for old city's transformation, without building too much low density flat layer and will achieve the change that closed community to blocks; Strengthening based facilities construction to satisfy people's needs; Increasing the supply of affordable house and improve the availability of rental house and more households unit to reduce the housing pressures which brings by increasing population;

(2) In environmental protection projects. We should not only take into account the conservation of existing resources, but also should through implementation of the policy to make green areas, farmland and other resources being sustained growth to satisfy the growing demand.

(3) In terms of transportation planning, increasing investment in transport and making buses play a leading role. And ensure the quantity of per million people has buses should satisfy international standards.

(4) Economic development continues to comply with our plans that have been given in the mandate three. Supporting the development of high-tech industries and encouraging entrepreneurship. Also, Guide the transformation of urban industrial institutions. Which all can create more employment opportunities and create more revenue for the government.

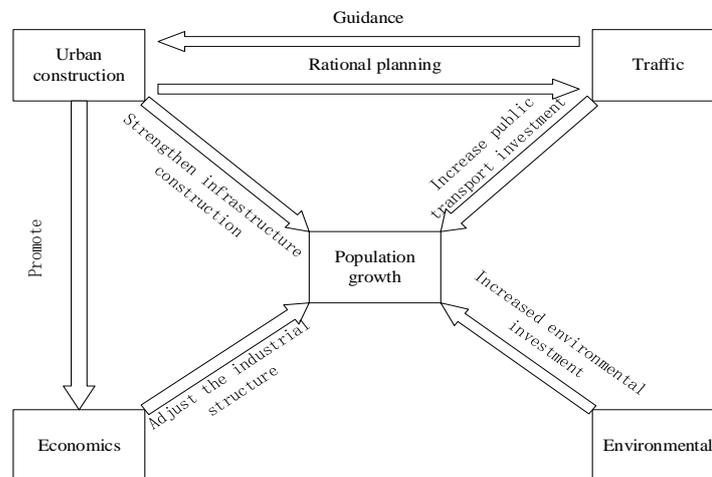


FIG.5 Policy relevance graph

8. Strengths and Weaknesses

8.1 Strengths

- We set up a total index database through the collection to the national index system, which considers more factors and is thus better suited to most cities.
- High factor weight, Good stability model.

8.2 Weaknesses

- We only consider the observable data, do not delete the observable data. But in real life, a city of people's ideas, the cultural characteristics of the city's soft power has a certain impact on the city smart growth. In the development of urban growth plan, we give the expected goal is the city's current level of intelligence and the development of relevant international standards.
- We use the analytic hierarchy process to calculate weights, this subjectivity is too strong
- Large amount of computing, and the actual operation is more difficult.

9. Future Work

Since there are many weaknesses in our work, plenty of efforts can be spent in the future to improve our work.

Firstly, relationship between parameters will be our top consideration in the future.

In this paper, we only considered a few of them. Considering the large amount of parameters, it is impossible that they are totally isolated from each other. For example, the value of social culture are correlative in practice, so the variation should be related.

Secondly, We can improve our model from the weight calculation. By doing so, we may even discover differences and will probably improve our model even future. More importantly, we can apply our model to Other cities and test its feasibility.

Because we are selected based on the ten principles of three E and smart growth indicators of sustainable development, in general, these indicators can be widely used in the intelligent evaluation of the city at home and abroad. But to the development of intelligent city level detailed evaluation must take into account many non measurable indicators such as a city of people's ideas, the cultural characteristics of the soft power of the city, the city of intelligent growth has certain effect.

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